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ABSTRACT

This final report in the MicroSIFT series reviews 10 software packages that deal mainly with the areas of electricity, magnetism, and heat energy. Software titles appearing in this report were selected because they were judged to be exemplary according to various criteria in the MicroSIFT Evaluator's Guide, with some additions to address science directly. All of the software serves to supplement regular classroom laboratory instruction. Basic computer-based tool packages were included for temperature-dependent experiments. Although the computer-based tool packages do not directly relate to electricity and magnetism, they do provide a steppingstone into using the computer as a tool to aid scientific discovery. Software packages are divided between those that use thermistor probes as lab tools and electricity and magnetism concept development software. (KR)

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SOFTWARE FOR MIDDLE SCHOOL PHYSICAL SCIENCE

A CRITICAL REVIEW OF PRODUCTS

Zita Podany

November 1990

A MicroSIFT Report

Northwest Regional Educational Laboratory
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INTRODUCTION

The improvement of science education is an important issue in the nation. In particular, improvement is being sought in curriculum and instruction at elementary and middle school levels. Many scientists and science teachers believe that an increase in the amount of "hands on" activities in science will provide students with a more accurate concept of what real science is, and make the study of science more interesting. Activities based on or supported by computer software can help to make the study of science more realistic and motivational.

This is the final report in the MicroSIFT series. The project is coming to an end after ten years. We have made an effort in the last five years to focus our software review and evaluation efforts on topics which are of current high interest in education. We can think of no more important subject for now and the future than science. There are several hundred software packages applicable to middle school science. In order to conduct an adequate review, we have included in this report only those in Physical Science, particularly in the areas of Electricity, Magnetism, and Heat Energy.

Software titles appearing in this report were selected because they were judged to be exemplary according to various criteria in the MicroSIFT Evaluator's Guide, with some additions to address science directly. The titles are representative of the best software in a much larger pool of titles which are available for this topic and level. All of the software serves to supplement regular classroom or lab instruction and should not be used as a sole source of instruction or concept development. Also, it should be noted that nothing can replace hands-on activities/experiments in the lab. With most of the programs, students should be encouraged to try some of the simulated experiments presented in the lessons. In using the programs, guided inquiry would focus on key concepts to be learned, in which case, the teacher needs to preview the software and design questions and activities to maximize the learning experience. Basic computer-based tool packages were included for temperature-dependent experiments. Although the computer-based tool packages do not directly relate to electricity and magnetism, they do provide a steppingstone into utilizing the computer as a tool to aid scientific discovery. Also, for the more advanced students in electricity, a discussion on how thermistor probes work would certainly fall into the realm of electrical circuitry.

PRODUCT DESCRIPTIONS

SOFTWARE PACKAGES UTILIZING THERMISTOR PROBES AS LAB TOOLS:

Exploring Heat Thru Lessons and Labs

Producer:	D.C. Heath (sold and distributed by William K. Bradford)
Price:	$160.00
Audience:	4-8
Hardware:	Apple II+, IIe, IIc, 64K; two disk drives are recommended especially for making, changing, or copying student disks.
Optional Hardware:	Grappler + card (for printing graphs). Compatible printer.

Description: An elementary tool package allowing students to investigate principles of heat energy through experiments and class activities. With the two thermistor probes, students can study and record behavior of water under various conditions (i.e., at room temperature, freezing and boiling points). Data can be collected, graphed, saved to a student's data disk, and printed.

Package includes a back-up master disk and a teacher's guide complete with lesson plans, student activity sheets, and a Lesson Organizer and Materials Chart. Side one of the master disk contains the teacher disk which is used to run any student disk, print graphs, and create, modify, or copy student disks. The standard student disk is on side two of the master disk; it contains the software programs students will be using. The teacher, in creating individual student data disks, can select which programs and special features should be included on each disk.

There are four programs on the student side of the master disk: *Lab Tools, Dictionary Entries, Quizzes,* and *Games.* The *Lab Tools* program uses temperature probes to investigate the nature of heat energy under certain types of conditions. The activities include *Molecule Window*, which allows students to see how different water temperatures affect molecular movement.

A Grappler + card is required to print graphs. However, the manual states that interface cards capable of printing high-resolution graphics screens can be used for printing graphs from student disks. The manual also identifies some software capable of printing these graphs with various serial or parallel interface card-printer combinations.

Evaluation: Although this is a very simple and limited type of program, it does provide a nice introduction into the world of microcomputer-based labs through which students can become accustomed to utilizing the computer to record data in much the same way scientists use more sophisticated instruments. The program is simple enough so that it is easy to operate. The suggested activities in the accompanying teacher's manual are designed for group and class investigations. A negative aspect of the program is its calibration feature. In order to calibrate the probes, two solutions must be prepared, one at boiling and the other at freezing point. The computer then automatically calibrates itself once the probes have been placed in the specified solution. No numbers are displayed, just two columns fluctuating up and down appear on the screen. The user does not have much control over the calibration process.

EduTech's CompTrol Lab: Temperature

Producer:	EduTech
Price:	$195.00

Audience: 5-12
Hardware: Apple IIe, IIc, IIGS

Description: The temperature module includes an interface box and two temperature probes. In order to perform temperature experiments, at least one temperature probe must be plugged into port 1 of the three-port *Temperature Module* and up to three temperature probes can be read at the same time (only two probes function on a IIc).

This module allows students to perform temperature measurements, obtaining readings with 0.01°C precision at room temperature. Data is collected for later review and can be saved to a disk. As measurements are being made, the temperature readings can be displayed either as large numbers on the screen (for class demonstrations), or plotted as a continuous graph. The user has the option of choosing either the Fahrenheit or Celsius scales. Students can also set the upper and lower limits if the graphing option is chosen. The graph can be printed out on most printers.

Evaluation: The program is easy to use and does provide some flexibility in how students can view temperature measurements. Data recorded by the computer can be printed out for further examination. A negative aspect of this program is that students can only view data collection in one way, either as large numbers or as a graph. Once the selection is made, students are stuck to that display, unless they redo the measurements. It would have been nice to be able to switch back and forth from the large-number display to the continuous graph. Also, I found that upon saving results to disk, it did matter which mode I was in when the save command was executed. With a large-number display, and two probes, the program saved the last large-number display collected for the two probes. With the graphical display, the computer saved the whole graph.

Calibration routines are built into the program providing a digital readout which gives the user some control over the process.

Exploring Science: Temperature
Producer: Sunburst
Price: $129.00
Audience: 6-12
Hardware: Apple II family

Description: Students can investigate the properties of temperature by using the probes to help them gather and analyze data. Data can be saved to a disk and any further updates to the experiment can be added to previously saved data. Includes three color-coded thermistors capable of monitoring temperatures ranging from -20°C (0°F) to 120°C (240°F) in up to 1 molar solutions.

Data collection can be displayed in one of four different modes, including time vs. temperature line graphs, and a large digital display ideal for whole-class investigations. Over 6,000 data points can be stored on disk. The program includes built-in statistical functions to aid students in performing calculations on their measurements.

Evaluation: The teacher's guide provides extensive ideas and lesson plans for implementing the use of thermistor probes as lab tools to aid the science exploration process. Also included are instructions on how to make your own thermistor probes and extension cables. Although the program is relatively easy to use, teacher demonstration is a must.

Playing with Science: Temperature
Producer: Sunburst
Price: $129.00
Audience: 0-7
Hardware: Apple II family

Description: The program is designed to provide students with an opportunity to investigate concepts of heat and cold through various lab experiments utilizing temperature probes. Includes three color-coded thermistor probes.

Evaluation: The manual provides many experiment ideas to help students grasp concepts of temperature. If thermistors probes should become lost or damaged, instructions are provided on how to make them (if the user is so inclined). Although the program is easy to use, teacher guidance is recommended.

ELECTRICITY AND MAGNETISM CONCEPT DEVELOPMENT SOFTWARE

Electricity and Magnetism

Producer:	Educational Activities
Price:	$59.95
Audience:	4-8
Hardware:	Apple II family, 48K; IBM, PC JR., MS-DOS compatibles, 128K, requires a color monitor

Description: A basic introduction into the field of magnetism and electricity. Sequential lessons guide the student through concepts of magnetism and then into electrical circuits. In learning about static electricity, students experiment with a simulated gold-leaf electroscope to discover how electrical and magnetic properties differ from one another. In exploring electrical circuits, students learn about conversions from chemical and mechanical energy into electrical energy. Through simulated electrical on-screen activities, students can experience connecting series and parallel circuits, culminating in a detailed look at Ohm's Law.

Package includes program disks and back-ups, management documentation, lesson plans and ideas, and reproducible activity masters.

A management system keeps track of student progress and regulates access to programs on the disk. Students move sequentially through each lesson and upon completion of all four parts, they are given a choice as to which programs they would like to try again. This latter option presents itself only when the student has completed all lessons on the disk, otherwise, the management system would automatically place the student after sign-on.

Evaluation: Small amounts of information are presented at a time which is a good strategy for an age group that could easily become overwhelmed with full-text screens. Feedback is positive even when the wrong answer has been entered. When a student responds correctly, the program emits positive sounds along with phrases such as, "You're a magnetic polar bear!" When the wrong answer has been keyed in, no sound is emitted but textual information is displayed, "the correct answer is ----."

Some parts of the program are slow, especially those involving animated graphics. The user must wait until the action is completed before continuing. Some words include pronunciation keys next to them, enabling students to not only learn new concepts but also how to pronounce key words. For a student redoing a lesson, these features can become annoying once the novelty has worn off and the action takes too long to execute. Too bad there isn't a feature for those repeating the lesson to hide the pronunciation keys and cut short some of the animation in order to progress to the next screen.

Some students might get confused with the analogy of electrons through a wire being like the flow of water through a pipe. If a valve is closed on a water pipe, flow ceases; whereas if a switch is closed in a circuit, current flows. This is a distinction that needs to be made lest students get the wrong impression from the oversimplified analogy.

Overall, each of the lessons provide useful information broken down into bite-sized chunks sure to hold student interest. Graphics and animation serve to illustrate textual examples, thus further reinforcing concepts and providing a chance to examine causal relationships. Feedback is positive and, in the case of wrong answer inputs, nonthreatening.

Electricity and Magnetism

Producer:	D.C. Heath (distributed by William K. Bradford)
Price:	$70.00
Audience:	4-8
Hardware:	Apple II family, 48K

Description: A basic introduction to electricity and magnetism. The program is designed as a game, requiring students to apply what they know about basic circuits and functions of various circuit devices. The disk contains thirty-two circuit puzzles or Quests, each with missing electrical components. The missing items are buried somewhere on an island. Students embark on Quests in search of specific items that will complete their target circuits. The map of the island is divided into sections, creating a 6x10 grid. Users go to a specific coordinate and "dig" for the item that will complete the circuit in their Quest. The found items are placed into the circuit and tested. If it is a device that satisfies the task, then students progress to the next Quest, if it isn't, then they must keep searching until they find the component that will perform the required function.

Quests are arranged in three categories: *Basic Circuits; Parallel and Series Circuits;* and *Review*. In *Basic Circuits*, students apply their knowledge of electric components and how they relate to building simple circuits. *Parallel and Series Circuits* provides a comparison between the two types of circuits and their advantages and disadvantages under certain conditions. The *Review* portion combines concepts learned in the two previous Quest categories.

Evaluation: This program could be used for added reinforcement to classroom investigations in electricity and magnetism. By itself, the program could prove to be frustrating to those students not familiar with basic concepts of circuits. Students embark on various Quests of finding circuits devices that perform specified functions. Careful attention to detail of the circuit element is a must, some are burned-out devices and look very much like the "working" components. These games require students to apply what they know about circuits and various circuit elements in order to make wise choices as to where on the grid they should look to find the object of their choice.

Since the map is represented as a 6x10 grid, students must go to a specific coordinate in search of the device needed to complete their task. Movement from one coordinate to another is done with arrow keys, which after awhile can become very tedious. It would be preferable to input desired coordinate points rather than using arrow keys to navigate from one point to another.

A management system keeps track of student responses and progress. The teacher's manual offers ideas on how to use the program to provide added reinforcement of electricity and magnetism concepts. Reproducible worksheets are included.

Due to the management system and number of graphics, the program is slow, thereby making the games too time-consuming although innovative in format. Also, upon first using the program, it is hard to determine what actions are expected when facing a picture representing one portion of the map. The program seems to position itself at a default grid location (8,1), showing a confusing graphic which does not shed any light as to what actions should be taken. Digging in this area leads to a natural tendency to somehow relate the picture to the buried item. If the default location was in a "grassy" area, that tendency would not be as prevalent. As with any program to be used with students, the teacher needs to model the expected actions at least once to give students a general idea of how the program works.

Heat Energy

Producer:	D.C. Heath (sold and distributed by William K. Bradford Publishing Company)
Price:	$70.00
Audience:	5-8
Hardware:	Apple II+, IIe, IIc, 48K

Description: This program enables students to understand some of the factors involved in building shelters based on location and climatic conditions. Students design and construct simulated shelters for various geographical locations. Their shelters are then tested in terms of strength and temperature comfort. Students get to see how the various environmental factors influence the type of structure to be built in that region.

Evaluation: Students must make choices based on available factors in the program, which makes the program somewhat limited in scope. Also, students are not given a chance to predict the outcomes of their choices prior to the program evaluating their decisions.

Electric Current Models: Understanding Ohm's Law

Producer:	Conduit
Price:	$75.00
Audience:	6-16
Hardware:	Apple II+, IIe, IIc, IIGS, 64K

Description: Introductory presentation of the free electron model for electric current with a brief review of Ohm's Law and its derivation from the free electron gas model. Animated graphics serve to emphasize cause-effect relationships and provide the user with a visual example of the concept under study. The disk contains five lessons: *What is Current*; *Measuring Current*; *Discovering Ohm's Law in the Laboratory*; *Ohm's Law as a Scientific Model*, and *Ohm's Law and the Free Electron Gas Model.*

Evaluation: A good introduction to the study of electric current in terms of an electron gas model. Students, who have had a hard time understanding how Ohm's Law works and how it was derived, will gain added insight into this topic. The information displays are informative and provide visual clarification of key concepts. At the most elementary level, students can see the effect of using a switch in an electrical circuit upon electron flow. At the more advanced level, students are presented with the free electron gas model and Ohm's Law. Should a student pause too long at any one screen, a prompt appears reminding the student to respond, "select with arrow keys; press return."

The program is self-contained and easy to use. However, the documentation is brief and does not include any lesson ideas or activities. As this software was designed to accommodate varying levels of expertise, some teacher guidance is necessary to ensure proper lesson placement.

Basic Concepts of Electricity Series

Producer:	Merlan
Price:	$295.00 (complete package of four modules); individual modules sold at $95.00 each
Audience:	6-12
Hardware:	Apple II family; Commodore 64; PET, 32K

Description: A series consisting of 16 programs encompassing tutorials, drills, simulated lab exercises, and diagnostic tests covering topics from electrical charges to electrical energy and its cost. Each program includes specific objectives, graphics, animation, drills, and feedback. Drills

and tests are created randomly from a data bank thus ensuring a more than one-time-through lifetime of the programs. Documentation includes program overviews, detailed objectives, and teaching ideas/recommendations.

Evaluation: Each lesson starts with a specific learning objective to which student performance can be gauged. The interactive lessons interspersed with animated sequences are presented in a clear, concise manner that is easy to follow. Overall, screen displays are not cluttered with too much text or graphical detail, although there are a few exceptions. Information is presented in manageable pieces so students won't feel overwhelmed with too much too soon. Each lesson provides an ample supply of questions to measure student understanding of covered material. Feedback is immediate and, depending on the nature of the question, only one attempt is allowed for incorrect responses, although in some areas two attempts are permitted for entering a correct response.

Alternating Current Series

Producer:	Bergwall Educational Software
Price:	Introduction to AC, $79.00; Current Voltage and Power, $59.00; Magnetism and Electromagnetism, $79.00
Audience:	6-12
Hardware:	Apple II+, IIe, IIc, 48K

Prerequisites: Basic understanding of direct current.

Description: Tutorial courseware covering topics related to alternating current encompassing: *Introduction to AC*; *Current, Voltage and Power*; *Magnetism and Electromagnetism*; *Inductors and Inductive Reactance*; *Transformers*; *Capacitors and Capacitive Reactance*; and *Inductors and Capacitors in AC circuits*. Student performance is monitored by a built-in management system which can aid teachers in pinpointing weak areas.

Introduction to AC, contained on two diskettes, covers basic concepts of alternating current, includes topics on: Where AC is Used; Calculating Current Flow; Nature of AC, study of the changes in magnitude and direction of an AC voltage or current wave plotted as a voltage wavefront on the screen while simulating a rotation of a single-coil AC generator through one full revolution.

Further properties of alternating current are explored in *Current, Voltage and Power*. Topics cover: How AC is Measured; AC Laws; Measuring AC Power. Students are introduced to concepts of amplitude, positive peak value, negative peak value and peak-to-peak voltage and how these values are obtained from a given wavefront. In this section students also learn how to correctly connect AC voltmeters, AC ammeters, and wattmeters in order to obtain accurate readings.

In *Magnetism and Electromagnetism* (contained on two diskettes), students are presented with principles of magnetism, electromagnetism, and electromagnetic cm components and devices. Explains ferromagnetic, paramagnetic and diamagnetic materials, and their susceptibility to the process of magnetic induction.

Inductors and Inductive Reactance (two-diskette program) deals with electromagnetic induction, self-induction, what inductors are and how they work, and measuring inductive reactance. Symbols used to represent inductance and inductive reactance are also introduced.

The unit on *Transformers* discusses what transformers are and how they work by the principle of mutual induction. Explains the function and reasoning behind step-up and step-down transformers.

Capacitors and Capacitive Reactance introduces students to topics dealing with the nature of capacitors - what they are, how they work, and their units of measure.

Each of the units described contains a summary lesson reviewing the key concepts covered in each lesson. A quiz follows each unit and progress is based on individual performance.

Evaluation: Although the management system can provide detailed information as to the progress of a student, viewed in individual or group chart format, the diskette packages have no hard-copy printout capability. In order to obtain hard copies of progress reports on the screen, a FingerPrint Plus printer interface card has to be installed into the computer (information about this card can be obtained from Bergwall).

The ability to scroll back to previous screens is a very helpful feature for students who might want to go back and reread certain portions of a lesson. The screens are numbered and when a student experiences difficulty, as measured on the unit quiz, he/she may be referred to a particular screen in the lesson for further review. Upon completion of a quiz, students can view their progress report and select options available to them based on their quiz results, such as being able to skip the next tutorial and going on to the next quiz, or going back to a previous lesson or screen for added review. When the computer determines a student needs to go back over the lesson or specific screens of information, the quiz must be taken again. However, the original answers are still displayed and the student needs to erase them first to enter in a new answer. Simply entering the letter of the answer does not record the new answer. This is a vital piece of information that needs to be explained to the students, otherwise they may repeat the same test several times not knowing why they are told they answered incorrectly.

The graphics and animation are a strong point in this courseware for they add to the understanding of concepts and at times provide valuable simulated activities that otherwise might not occur due to time limitations. Especially useful is the visualization of the changes in magnitude and direction of an AC voltage or current wave. Without the need for more expensive instruments, such as an oscilloscope, students can see the sine wave produced by manipulating an on-screen generator through one complete revolution.

It should be emphasized that this program is intended for students who have a basic understanding of concepts related to direct current, have had some experience in reading and interpreting meters, and who have some knowledge of Ohm's Law. As this courseware is pretty well self-contained, it can be used as a supplement to regular instruction or as an enrichment or independent study activity for the more advanced students.

Scientific Models: Batteries and Bulbs, and Families

Producer:	IBM
Price:	$54.00
Audience:	4-8
Hardware:	IBM Personal System 12 Model 30, Model 50, Model 60, or IBM PC convertible, 256K

Description: This particular disk is part of the Scientific Reasoning Series designed to assist middle and high school students develop thinking and reasoning skills using scientific methods. There are two programs on the disk that are designed to give students experience in forming simple scientific theories. *Families* deals with Mendelian genetics and *Batteries and Bulbs* deals with principles and laws governing electrical circuits.

These programs are based on the discovery method of learning and implement dialog activities which are intended to guide the students into developing conceptual thinking skills.

The *Batteries and Bulbs* program introduces students to rudimentary topics dealing with electrical circuits. Students progress through eight activities: *Light the Bulb; Battery and Bulb Arrangements*, an activity in which students learn which arrangements of wires, bulbs, and batteries work to light the bulb; *Other Things in the Circuit*, learning about conductors and

insulators; *Scientific Model of a Circuit*, where a circuit is analogized to that of the cooling system of a car in order to develop the concept of electrical current in a circuit; *Two Bulbs in the Circuit*; *Obstructing Current*, an introduction to resistance; *Current Paths*; and *Multiple Paths*, dealing with parallel circuits.

Evaluation: A well-thought-out program leading students to understand the basic principles behind electrical circuits. Progression is logical and divided into manageable activities. Operation of on-screen circuit devices via the keyboard have been simplified for ease of use. However, there are times when using the keyboard to connect a battery, bulb, and wires is far more time-consuming than if the student were to connect the real items.

Graphics and animation serve to reinforce conceptual understanding of how the various circuits and circuits devices work. Feedback is appropriate and encouraging even though at times it is unclear as to how to phrase an answer in an acceptable format.

The topics discussed are quite basic and assume no requisite knowledge skills in electrical circuits. Therefore, presenting the analogy of current to the cooling system of a car might be confusing to students with no conceptual framework in this area.

A similar type of program for the Apple II family, dealing with the basic principles of circuits, that has been determined to be useful is *Making Circuits* by Microcomputer Workshops Courseware. Although it is more structured, it does provide students with computer-based experiences with basic series and parallel circuits. It utilizes animation and user interaction to develop a conceptual base to this topic.

PRODUCER CONTACT INFORMATION

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Conduit
University of Iowa, Oakdale Campus
Iowa City, IA 52242
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319/335-4100

D.C. Heath Software
(sold and distributed by William K.Bradford Publishing Company)
Director of School Division
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2700 North Richardt Ave.
Indianapolis, IN 46219
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Educational Activities
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IBM
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